(γ,n) reactions : Do we care about them?

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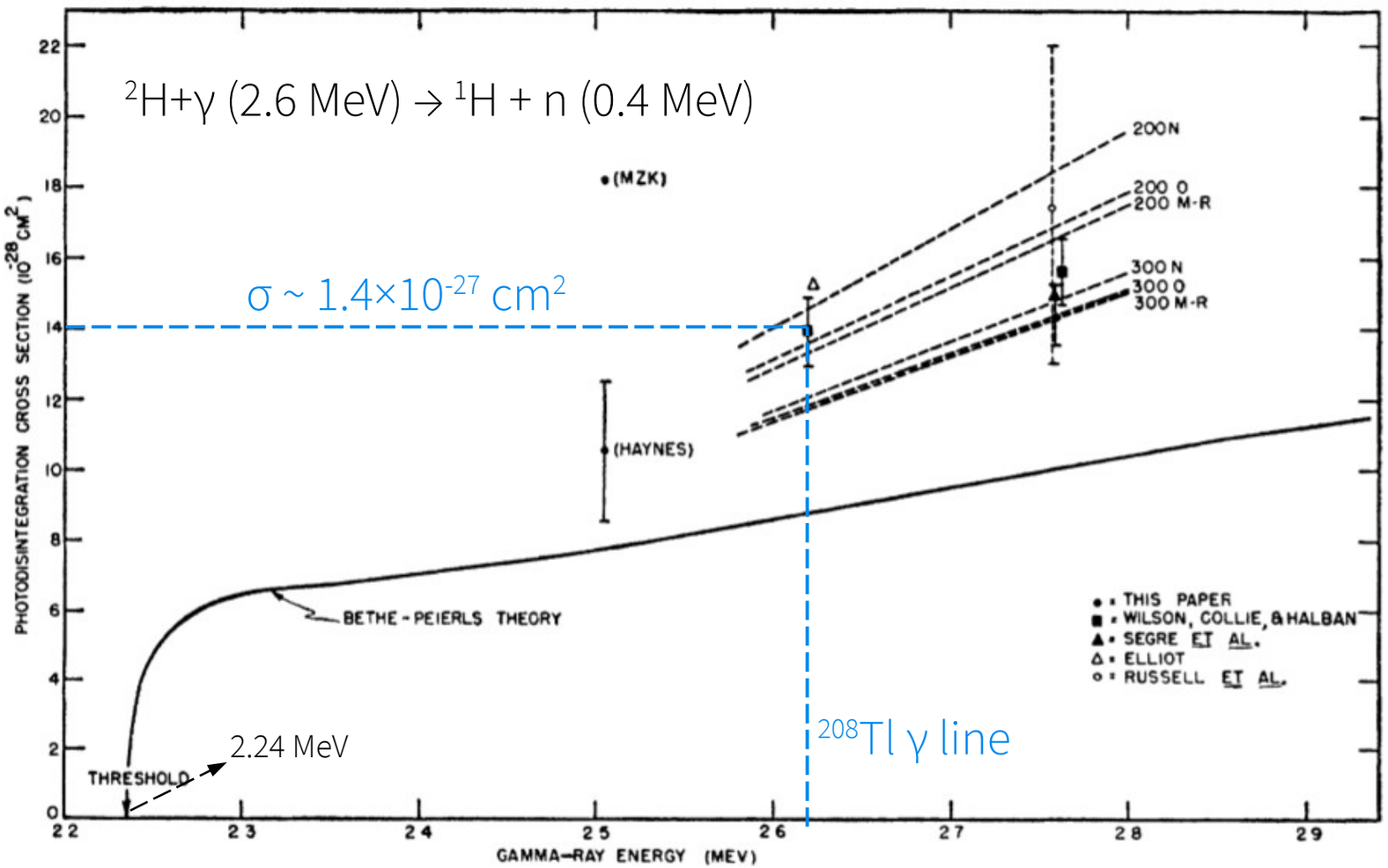
5 Oct 2021
Materials Meeting

$^{2}H(\gamma,n)^{1}H$ reactions in acrylic $(C_5O_2H_8)_n$

(reminder: ^{2}H has a natural abundance of 0.02%)

FIG. 2. Cross-section data on the photodisintegration of the deuteron. The dashed lines are drawn through the points at 2.62 and 2.76 Mev as calculated theoretically by Hansson and Hulthén; the figures 200 and 300 refer to the assumed meson mass, and *N*, *O* and *M-R* refer, respectively, to calculations based upon the neutral meson theory, no interaction in the ^3P state, and the Møller-Rosenfeld theory. The experimental points attributed to Elliott and Segrè have been quoted by Wattenberg [A. Wattenberg, "Photoneutron Sources," Preliminary Report No. 6, Nuclear Science Series, Division of Mathematical and Physical Sciences, National Research Council]; the former has also been quoted by Sargent [B. W. Sargent, National Research Council of Canada, Division of Atomic Energy, Report PD-206, unpublished.]. The two points at 2.50 Mev are derived according to discrepant measurements of the intensity of this gamma-ray in Ga^{72} (see text).



Snell, Barker, and Sternberg. "Photo-Disintegration Cross Sections of Deuterium and Beryllium for the Gamma-Rays of Sodium 24 and Gallium 72" Phys. Rev. 30, 4 (1950)

Quick (n,γ) probability estimate

- $(1.18\ g/cm^3)\times(1\ mol\ PMMA/100.12\ g)\times(8\ mol\ H/1\ mol\ PMMA)\times(0.0002\ mol\ ^2H/1\ mol\ H)\times(6.022e23\ ^2H/mol) = 1.14e19\ ^2H/cm^3$
- $\lambda = [(1.14\times10^{19}\ cm^{-3})\times(1.4\times10^{-27}\ cm^2)]^{-1} = 6.29\times10^7\ cm$
- Acrylic thickness = 5 cm
- $P_{(\gamma,n)} \sim 1\text{-}exp(-5/6.29\times10^7) = 8\times10^{-8}\ n/\gamma$
- These neutrons will have ~400 keV and be produced preferentially moving toward the TPC (since γ's come from outside)
- What is the flux of 2.6 MeV γ's incident on the PMMA?
  - Note: All γ's incident on the PMMA can contribute, including those from other materials like the PDU's (unlike for (α,n), where only α's emitted in the material matter (ignoring boundary effects)

How does this compare with (α,n) rates?

Estimate by Roberto

- (α,n) neutrons in $C_5O_2H_8$ are mainly produced by ^{13}C (1% nat. ab) with smaller contributions from ^{17}O and ^{18}O.
- The (α,n) cross section for ^{13}C is ~1×10^{-25} cm^2
- The abundance of ^{13}C is 44× higher than the abundance of ^{2}H
- ^{13}C(α,n) cross section is about 70× higher than ^{2}H(γ,n)
- There are ~16× more α's in the ^{232}Th decay chain than there are 2.6 MeV γ's
- ***Commentary from Shawn:*** *The acrylic is fairly radiopure. The question to me is if we need to be concerned about γ's from other materials incident upon the PMMA, rather than γ's originating in the PMMA itself*

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